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Marly Subsoils and the Chlorosis or Yellowing of Citrus Trees.

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It was early ascertained by this Station, and has been repeatedly stated in its publications, that the great majority of California soils, in common with those of the arid regions generally, is calcareous in the sense of containing lime enough to produce all its advantageous effects. In the East, and in the humid region generally, these effects have very frequently to be brought about by artificial liming or "marling"; an operation which but very rarely is of practical use in this State.

It is also well known that "overliming," or the use of too much lime or marl, is very injurious to many culture plants. The case in point best known is probably that of the phylloxera-resistant grapevine stocks brought to France from the Northern United States. The soils in the grape-growing regions of France are very commonly marly, and the result was the chlorosis, or yellowing of the leaves, and general failure of the American stocks on soils whose lime-content would not affect the European vine injuriously at all. The latter is credited with enduring even as much as 40 per cent of lime carbonate in the soil, while some of the American resistants are injured by as little as 5 per cent. of the same. Hence the mission, a number of years ago, of Professor Viala of Montpellier with a view to finding, in the strongly calcareous lands of Texas, a phylloxera-resistant grapevine which would also resist chlorosis. Viala was successful in this quest, and the stocks and hybrids obtained from the Texas vines now form the main basis of "reconstituted" vineyards in France.

Marly or excessively limy soils are quite exceptional in California, so much so that until quite recently only one case of chlorosis resulting from that cause had come to the knowledge of the Station. The yellowing of orange and lemon leaves, not uncommonly observed at some points in southern California, has throughout been due to other defects in the subsoil, which weakened the root-growth or gave rise to fungous disease.

Citrus orchards in the Great Valley have thus far been remarkably free from some of the troubles noted south of the Tehachapi; the chief complaints having been caused by the effects of water-seepage from high lying ditches in the foothills. The soils themselves have not been found in fault except where it was attempted to plant orchards on heavy clay subsoils, or hardpan; emphasizing the need of a careful examination of the substrata of any land designed for tree culture.

Quite lately, however, complaints of yellowing and languishing of citrus trees grown in apparently the best quality of loam soil in the Porterville region have come to the Station. Portions of young orchards planted on low ridgy land were found to become diseased, their leaves yellowing and dropping; while those located in lower ground continued to grow thriftily. The samples of soil and subsoil (the latter taken to the depth of from 3 to $5\frac{1}{2}$ feet in accordance with the directions given from the Station) showed that while in the lower ground where the trees were in good condition, the subsoil at 3 feet contained only 12 per cent. of lime carbonate, on the higher land it was full of white lime-nodules in the third foot; and that the fine earth around them, in which the roots vegetated, contained from 22 to 39 per cent. of lime carbonate. This evidently exceeds the tolerance of citrus roots, hence the yellowing of the leaves. In another similar case, examination showed that even where the trees were doing finely (the soil being very rich), the calcareous layer was reached at from $4\frac{1}{2}$ to $5\frac{1}{2}$ feet. It is probable that so soon as with progressive growth the roots reach the above depth they will here also be affected by the excess of lime.

This is a condition which perhaps cannot be remedied by any applications made to the land. When lands have been injured by artificial over-liming or excessive marling, the effects can be neutralized by the use of organic matter, usually applied in the form of stable manure, a procedure already prescribed in the classic treatise on *Marling*, by Ruffin of Virginia, early in the last century. But it is clearly impossible to apply this remedy in the case of lands naturally underlaid by marl; at least in the arid region, where roots penetrate to depths unknown east of the Mississippi. No vegetable material could be artificially applied at depths of several feet. Inquiry has been made whether it would not be possible to neutralize the lime by some acid; but this, even if financially possible, would surcharge the upper layers with a substance more injurious than the excess of lime itself. Possibly an antidote may be found in some soluble compound of magnesia.

Such lands should simply be given to some other culture than citrus trees; and among these, grapevines on their own roots, or upon some of the lime-resistant varieties developed in France, will be found available wherever the loose soil extends to 4 or 5 feet depth. Other cul-

tures resistant to marly soils are the fig, stone fruits on Myrobalan or Chickasaw-plum roots, and the quince; also most legumes.

It should be kept in mind that calcareous geological formations extend along the Sierra foothills from the Merced River south through Fresno and at least northern Tulare County, and can be observed in the bluffs of the streams as they emerge from the foothills. It is perfectly easy for any one to test these whitish materials for lime, and to recognize the lime hardpan in subsoils, by a few drops of muriatic or nitric acid, or even strong vinegar; which will cause them to "effervesce" or "fizz" from gas bubbles driven off by the acid. A bit of chalk or limestone can be used for comparison, thus gaining some idea of the liminess of the material. Long low ridges extending valleyward from the foothills may be suspected of being marly, and should be examined as to the nature of their subsoil before planting. Entirely similar conditions exist locally in portions of the Santa Clara River Valley, and on some other Coast Range streams in the south. Also at a few points in the Santa Cruz Range.

The matters discussed above emphasize from an additional point of view the need of subsoil examination in the arid region especially, because of the deep rooting of all plants and particularly of trees. It seems desirable to call attention to another and very obvious mode of recognizing any unusual conditions of soil and subsoil, *viz.*, the *native vegetation*. I have elsewhere* discussed somewhat elaborately the importance of the observation of native growth by landseekers and farmers. It may be said in brief that the native vegetation is ordinarily the outcome of centuries and millennia of "natural selection," which results in the predominance of the species of plants best adapted to the surroundings as a whole, and to the soil in particular. Hence such native growth must be presumed to express the same facts and adaptations which we subsequently find out laboriously by the successes and failures of various crops. What we need is to be able to *interpret* correctly the indications presented to us by the native growth.

To some extent this has been and is daily done by farmers all over the world, who buy wild land in accordance with the indications of the tree growth where such exists. In many Eastern States the official assessment of lands is habitually based upon the natural tree-growth, and the judgment of experienced men on this basis is rarely at fault, and has even excited the envy of agricultural chemists.

In the eastern United States and in the humid region generally, the presence or absence of an adequate supply of *lime* in the soil is largely the determining factor of the vegetative character; more so even than the moisture conditions, which are commonly credited with being the chief governing condition.

In the arid regions, where lime is almost universally present in soils to the needful and useful extent, *moisture* is undoubtedly the

* "Soils," MacMillan Co., 1906.

dominant factor causing differences in native vegetation. We are therefore deprived to a large extent of the signs by which good lands are recognized by the Eastern settler, the more as forest growth is not so abundant in the arid region. We must, in order to utilize the indications of the soil-character by native vegetation, observe not merely the kinds and development of trees on the ground, but also the shrubby and herbaceous growth; noting not only the presence but also the absence of plants prevailing in the neighborhood, from certain portions of the area.

Every one in California knows the "alkali weeds," which tell him that the land on which they grow is more or less impregnated with salts; many have even now learned which of these plants indicate land which under present conditions it will not pay to try to reclaim. Now just as some plants will resist a greater or less amount of alkali salts than others, so some plants are tolerant of an excess of lime in the soil, while others will refuse to grow, or at least will not naturally be found occupying ground containing more than the limited amount of lime, which is in all cases desirable.

The infrequent occurrence of marly lands in California, already referred to, has been the cause of the fewness of observations made in regard to the distinctive natural vegetation of such tracts. It is evidently very desirable that such observations should be made for the benefit of future planters of orange orchards; and the marly ridges of the Porterville region afford a good opportunity for this purpose. Undoubtedly some of the shrubs and herbaceous plants prevailing elsewhere in that region will be found wanting on the marly ridges or belts. Among these will doubtless be the Lupins, which are very prevalent in the foothill and plains region of Fresno and Merced. Lupins require about one-half of 1 per cent. of lime, and some will resist as much as 2 per cent.; but marly soils such as those referred to above will certainly not bear any native Lupins. I doubt that even the gray sage will grow on land thus heavily impregnated. That, however, is a question of fact which those living on the spot should readily determine. If any such will send samples of the plants naturally growing on such lands to the Station, they would aid in the settlement of these questions.